# PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2000-073152
(43)Date of publication of application : 07.03.2000

(51)Int.CI. C22F 1/04
B23K 20/00
C21D 1/26
C21D 8/02
C22F 1/06
C22F 1/08
C22F 1/18
// C22F 1/00

(21)Application number : 10-257641
(22)Date of filing : 28.08.1998

(71)Applicant : UNIV OSAKA
(72)Inventor : SAITO YOSHIHIRO
UTSUNOMIYA YUTAKA
TSUJI NOBUYASU
SAKAI TETSUO

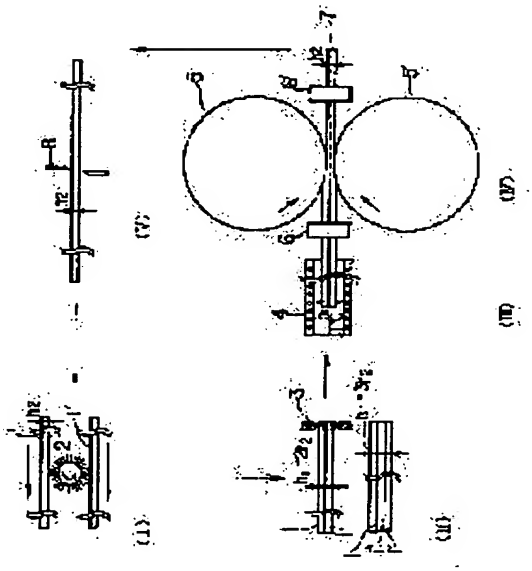


## (54) PRODUCTION OF SUPERFINE STRUCTURE HIGH STRENGTH METALLIC SHEET BY REPEATED LAP JOINT ROLLING

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a new producing principle capable of mass-producing a metallic sheet such as a wide thin sheet of a superfine structure high strength metallic material composed of fine crystal grains with ≤1 μm average grain size that is called super metal and to provide a method for producing it.

SOLUTION: In the method for producing a superfine structure high strength metallic sheet by laminating a plurality of metallic sheet and executing joint rolling, a stage in which a plurality of sheets 7 whose surfaces are cleaned are laminated, and the tip parts are joined, a stage in which the laminated sheets whose tip parts have been joined are heated to a temp. region less than the recrystallization temp. in which recovery occurs, a stage in which the laminated sheets heated to the temp. region less than the recrystallization temp. in which recovery occurs are rolled to the prescribed sheet thickness and are joined and a stage in which the joined and rolled laminated sheets are cut to the prescribed length in the longitudinal direction to form into a plurality of metallic sheets, and their surfaces



are cleaned are repeated by a plural member of cycles to refine the average crystal grain size of the metallic sheets to ≤1 μm.

---

LEGAL STATUS

| | |
|---|---|
| [Date of request for examination] | 28.08.1998 |
| [Date of sending the examiner's decision of rejection] | |
| [Kind of final disposal of application other than the examiner's decision of rejection or application converted registration] | |
| [Date of final disposal for application] | |
| [Patent number] | 2961263 |
| [Date of registration] | 06.08.1999 |
| [Number of appeal against examiner's decision of rejection] | |
| [Date of requesting appeal against examiner's decision of rejection] | |
| [Date of extinction of right] | |

---

## CLAIMS

---

[Claim(s)]
[Claim 1] In the approach of carrying out the laminating of two or more metal plates, performing junction rolling, and overly manufacturing a detailed organization high intensity metal plate The process which carries out the laminating of two or more metal plates which defecated the front face, and joins the point, The process which heats the laminate to which the point was joined in the temperature region where recovery takes place under with recrystallizing temperature, The process which rolls out the laminate heated in the temperature region where recovery takes place to predetermined board thickness, and is joined under with recrystallizing temperature, the process which cuts the laminate by which junction rolling was carried out to predetermined die length at a longitudinal direction, and defecates two or more metal plates, nothing, and these front faces -- two or more cycle repeat -- ****** -- by things it is based on repeat pile junction rolling characterized by making detailed the diameter of average crystal grain of a metal plate to 1 micrometer or less -- super- -- the manufacture approach of a detailed organization high intensity metal plate.
[Claim 2] In the approach of carrying out the laminating of two or more metal plates, performing junction rolling, and overly manufacturing a detailed organization high intensity metal plate The process which carries out the laminating of two or more metal plates which defecated the front face, and joins the point, The process which rolls out the laminate to which the point was joined to board thickness predetermined at a room temperature, and is joined, By cutting the laminate by which junction rolling was carried out to predetermined die length at a longitudinal direction, and heating two or more metal plates and the process which defecates nothing and these front faces in the temperature region where recovery takes place after two or more cycle repeat ******** and with under recrystallizing temperature it is based on repeat pile junction rolling characterized by making detailed the diameter of average crystal grain of a metal plate to 1 micrometer or less -- super- -- the manufacture approach of a detailed organization high intensity metal plate.

---

[Translation done.]

---

## DETAILED DESCRIPTION

---

[Detailed Description of the Invention]
[0001]
[Field of the Invention] it is based on repeat pile junction rolling with which this invention relates to the approach of making detailed crystal grain, such as a metallic thin plate of steel, aluminum and an aluminium alloy, copper and a copper alloy, nickel and a nickel alloy, titanium and a titanium alloy, magnesium and a Magnesium alloy, and all the other double width long pictures that can be manufactured with rolling, especially mean particle diameter consists of a fine crystal grain 1 micrometer or less -- it is overly related with the manufacture approach of a detailed organization high intensity metal plate.
[0002]
[Description of the Prior Art] the metallic material and chemical composition overly usual in a detailed organization high intensity metallic material ******** super metal which particle size becomes from a fine crystal grain 1 micrometer or less -- fundamental -- the same -- organization control -- engine performance, such as specific strength, toughness, and corrosion resistance, -- being fast (twice as many target as this) -- as for this, it is known [ which detailed-ization can overly attain ] about crystal grain although it is the improved metallic material. After raising dislocation density to a limit by strong strain cold working as a detailed-ized method of crystal grain, how to make recrystallization and a transformation cause can be considered, and the low-temperature large pressing-down rolling annealing method ( drawing 6 ) using liquid nitrogen, a shear extrusion method (the ECAP method) ( drawing 7 ), the mechanical milling method ( drawing 8 ) of fine particles, etc. are proposed, and attract attention recently. The low-temperature large pressing-down rolling annealing method performs recrystallization annealing, after repeating the process which rolls out thin slab at low temperature after cooling by liquid nitrogen etc., as shown in drawing 6 , and they are sheet metal and the approach of making. As shown in drawing 7 , after a shear extrusion method (the ECAP method) repeats the process which puts in a material into the die which has the hole configuration of an L type, pushes by the plunger, and gives a shearing work, it performs heat treatment and are the material of the shape of short slab or a rod, and the approach of making. As shown in drawing 8 , the mechanical milling method of fine particles gives each process of mechanical milling, solidification, and heat treatment to metal powder,

and are a block or a tabular material, and the approach of making.
[0003]
[Problem(s) to be Solved by the Invention] However, cooling and low-temperature maintenance of the ingredient like a roll turner are difficult, and by the low-temperature rolling annealing method, since it is constraint of a material and product board thickness, the large strain of arbitration cannot be given, but detailed-izing with a particle size of 1 micrometer or less is difficult. By the ECAP method, a long plate cannot be manufactured theoretically but there are problems, like manufacture of a double-width plate is difficult with a powder method.
[0004] The purpose of this invention is to offer the new manufacture principle and the manufacture approach overly of mass-producing industrially metal plates, such as double width sheet metal of a detailed organization high intensity metallic material ******** super metal, that mean particle diameter consists of a fine crystal grain 1 micrometer or less.
[0005]
[Means for Solving the Problem] In order to solve said technical problem and to attain the purpose, this invention uses the means shown below.
[0006] (1) In the approach of the manufacture approach of this invention carrying out the laminating of two or more metal plates, performing junction rolling, and overly manufacturing a detailed organization high intensity metal plate The process which carries out the laminating of two or more metal plates which defecated the front face, and joins the point, The process which heats the laminate to which the point was joined in the temperature region where recovery takes place under with recrystallizing temperature (temperature of a minimum from which recrystallization of a nucleation and a growth mold arises), The process which rolls out the laminate heated in the temperature region where recovery takes place to predetermined board thickness, and is joined under with recrystallizing temperature, the process which cuts the laminate by which junction rolling was carried out to predetermined die length at a longitudinal direction, and defecates two or more metal plates, nothing, and these front faces -- two or more cycle repeat -- ****** -- by things it is based on repeat pile junction rolling characterized by making detailed the diameter of average crystal grain of a metal plate to 1 micrometer or less -- it is overly the manufacture approach of a detailed organization high intensity metal plate.
[0007] (2) In the approach of the manufacture approach of this invention carrying out the laminating of two or more metal plates, performing junction rolling, and overly manufacturing a detailed organization high intensity metal plate The process which carries out the laminating of two or more metal plates which defecated the front face, and joins the point, The process which rolls out the laminate to which the point was joined to board thickness predetermined at a room temperature, and is joined, By cutting the laminate by which junction rolling was carried out to predetermined die length at a longitudinal direction, and heating two or more metal plates and the process which defecates nothing and these front faces in the temperature region where recovery takes place after two or more cycle repeat ******** and with under recrystallizing temperature it is based on repeat pile junction rolling characterized by making detailed the diameter of

average crystal grain of a metal plate to 1 micrometer or less -- it is overly a detailed organization high intensity metal plate.
[0008] In addition, about the diameter of 3mm extracted in parallel with a rolling side from near the board thickness core of the piece of a trial with a thickness of 1mm rolled out, and the thin film created by electrolysis jet polish from the flake with a thickness of 50 micrometers, about ten TEM photographs are taken, a grain boundary measures the diameter of 30-50 clear crystal grain, and the diameter of average crystal grain here says the value calculated by the average.
[0009]
[Embodiment of the Invention] As a result of repeating research wholeheartedly that the above-mentioned technical problem should be solved, in order overly to make detailed crystal grain of the metal plate of a double width long picture, to be stabilized and to manufacture a high intensity metal plate, this invention persons heated the plate in the temperature region where recovery takes place under with recrystallizing temperature, and acquired the knowledge that it was effective to give a large strain with repeat pile junction rolling.
[0010] Based on this knowledge, as this invention persons controlled rolling in the warm-rolling conditions of repeat pile junction rolling, or a room temperature, and annealing conditions within fixed limits, they completed a header and this invention for the manufacture approach which can overly mass-produce industrially metal plates, such as double width sheet metal of a detailed organization high intensity metallic material ******** super metal, that mean particle diameter consists of a fine crystal grain 1 micrometer or less.
[0011] The operation gestalt of this invention is explained below.
[0012] (The 1st operation gestalt) it is based on repeat pile junction rolling concerning the 1st operation gestalt of this invention -- the manufacture approach of a detailed organization high intensity metal plate [ overly ] In the approach of carrying out the laminating of two or more metal plates, performing junction rolling, and overly manufacturing a detailed organization high intensity metal plate The process which carries out the laminating of two or more metal plates which defecated the front face, and joins the point, The process which heats the laminate to which the point was joined in the temperature region where recovery takes place under with recrystallizing temperature (temperature of a minimum from which recrystallization of a nucleation and a growth mold arises), The process which rolls out the laminate heated in the temperature region where recovery takes place to predetermined board thickness, and is joined under with recrystallizing temperature, the process which cuts the laminate by which junction rolling was carried out to predetermined die length at a longitudinal direction, and defecates two or more metal plates, nothing, and these front faces -- two or more cycle repeat -- ****** -- it is characterized by making the diameter of average crystal grain detailed to 1 micrometer or less by things.
[0013] Before carrying out the laminating of two or more metal plates, the reason for having established the surface defecation (cleaning) process which defecates the front face of a metal plate From viewpoints, such as roll wear mitigation with junction rolling, mitigation of a roll load, and seizure prevention to the roll of an ingredient It is because it is activated while removing the thing and dirt with which

the lubricant (fats and oils etc.) supplied to a roll adhered to the metal plate front face and defecating the plane of composition of the metal plate by which the laminating was carried out, and junction like the following junction roll turner is enabled.

[0014] Moreover, after carrying out the laminating of two or more metal plates, the reason for having established the process which joins the point is for one increasing the junction force at the tip of the laminate in the case of junction rolling, and making junction easy. That is, for example with 50% of rolling reduction, between ** when cold-rolling, the junction force at a tip is sometimes inadequate, and a tip exfoliates in the shape of alligator with residual stress in that case, and it cannot join. Then, this exfoliation can be prevented if the tip is beforehand joined with several places, spot welding, the bolt nut, or the wire. The 2nd reason is that the adhesion of the plate on which the perimeter of not only a tip but a plate was put when joining partially several places (temporary stop) is secured, oxidation of the interface which checks junction can be controlled in case it is heating, and it can make junction easy as a result when piling up a cutting plate-like ingredient between ** and carrying out junction rolling.

[0015] That is, the manufacture approach concerning the 1st operation gestalt of this invention is an approach (2) mean particle diameter manufactures the metal plate 1 micrometer or less which overly consists of a detailed grain using the rolling approach of giving the large strain of arbitration, without changing (1) board thickness into the metal plate of a double width long picture, as shown below.

[0016] (1) The rolling approach of giving the large strain of arbitration, without changing board thickness (approach A)

A principle is shown in drawing 1 . That is, the plate of the double width long picture of two sheets or three sheets of the same dimension is left, and five processes of (I) cleaning + brushing (surface defecation process), (II) superposition (laminating) + point junction, heating (III), (IV) junction rolling, and (V) cutting + trimming are repeated.

[0017] (I) -- thickness h2 two -- a sheet -- a plate -- one -- one -- ' -- a plane of composition -- three -- a sheet -- a case -- in addition to this -- sandwiching -- having -- a plate -- one -- ' -- ' -- both sides -- degreasing -- the steel wire brush 2 -- using -- brushing -- a front face -- defecating . This surface defecation processing has the desirable thing which obtain good bonding strength as mentioned above and to perform for accumulating.

[0018] In (II), a point is joined for two sheets or three plates with a spot welder 3 or a bolt nut, a wire, etc. in piles, and it is thickness h1 =2h2. Or 3h2 It carries out. This point junction processing has the desirable thing for which a rolling gap of the plate in the case of junction rolling is prevented as mentioned above, and junction rolling is stabilized and to perform for accumulating.

[0019] In (III), it heats with a heating furnace 4 to the temperature requirement which can be joined without an ingredient producing a lug crack with junction rolling of (IV).

[0020] the board thickness (initial board thickness) h2 same in (IV) as the plate of a start up to -- an one pass or if needed, above a two pass, using a roll 5, 5', and the side roller guide 6 and 6', it carries out a pressure welding pressure total, and

unifies. Here, side roller-guide 6' also has the function of an edging roll.
[0021] the die length after carrying out cropping of the point back end of the plate 7 obtained in (V) by the cutter 8 and trimming the both ends of a plate if needed further -- 2 -- it divides equally or (in the case of a two-sheet pile) divides [ 3 ] equally (in the case of a three-sheet pile)
[0022] In the case of r= 50% of rolling reduction, and an equivalent strain epsilon= (2/root3) ln2=0. 80 or 3-sheet pile, the strain given to an ingredient at these five processes is epsilon=(2/root3) ln 3= 1.27 r= 67% in a two-sheet pile.
[0023] Therefore, if five processes of above-mentioned (I) - (V) are repeated n times (cycle), it is the rate rt of the bottom of total pressure. It sets by the two-sheet pile and is set to accumulation equivalent strain epsilont =nepsilon rt =(1-3-n) x100% by the three-sheet pile rt =(1-2-n) x100%.
[0024] In addition, in this invention, even if board thickness separates from desired value (initial board thickness: h2) from some in repeat pack rolling, the effectiveness of this invention is acquired. For example, even if it varies somewhat like 1mm -> 0.9mm -> 1.1mm -> 1.05mm, it is satisfactory in any way. However, when it separates extremely, there is a possibility of rolling reduction being insufficient and producing poor junction.
[0025] Moreover, it is also possible to increase board thickness gradually like 1mm -> 1.05mm -> 1.1mm -> 1.15mm in decreasing gradually like 1mm -> 0.95mm -> 0.9mm -> 0.85mm. However, since rolling reduction becomes smaller than 50%, effectiveness may fall a little or joining in the case of the latter may become inadequate. That is, if it is more than the rolling reduction that needs the rolling reduction of each pass for junction, even if board thickness will change somewhat, I hear that it is satisfactory and there is.
[0026] (2) The approach (approach B) approach A of manufacturing the metal plate with a particle size of 1 micrometer or less which overly consists of a detailed grain can give a big strain theoretically to infinity, unless the ductile limitation of a plate is arrived at.
[0027] Therefore, if (T) is set as the temperature region where recovery takes place under with the recrystallizing temperature (temperature of a minimum from which recrystallization of a nucleation and a growth mold arises) of an ingredient whenever [ before rolling in the process (III) of Approach A / stoving temperature ] It is recrystallization (that is, to the very high processing in-house of dislocation density) of a nucleation and a growth mold at the time of cooling after rolling, and heating before rolling. Many minute recrystallization nuclei in which dislocation density was surrounded by the very low and clear boundary generate, and when they grow quickly, the rise of the dislocation density by strip processing and the rearrangement of the rearrangement by recovery are repeated, without organization change which changes a processing organization to recrystallized structure taking place. In the process, crystal grain is divided into the cel of the structure with which detailed ****** (subgrain) or a detailed rearrangement became entangled while it is extended thinly, the subgrain which adjoins further, or the bearing difference of a cel increases, and subgrain or a cel serves as a super-fine crystal grain surrounded by the large inclination grain boundary. Consequently, the diameter of average crystal grain of a plate can be

considered as a detailed organization 1 micrometer or less.
[0028] (The 2nd operation gestalt) it is based on repeat pile junction rolling concerning the 2nd operation gestalt of this invention -- the manufacture approach of a detailed organization high intensity metal plate [ overly ] In the approach of carrying out the laminating of two or more metal plates, performing junction rolling, and overly manufacturing a detailed organization high intensity metal plate The process which carries out the laminating of two or more metal plates which defecated the front face, and joins the point, The process which rolls out the laminate to which the point was joined to board thickness predetermined at a room temperature, and is joined, The laminate by which junction rolling was carried out is cut to predetermined die length at a longitudinal direction. Nothing [ two or more / metal plate and nothing ], It is characterized by making detailed the diameter of average crystal grain of a metal plate to 1 micrometer or less by heating the process which defecates these front faces in the temperature region where recovery takes place after two or more cycle repeat ******** and with under recrystallizing temperature (temperature of a minimum from which recrystallization of a nucleation and a growth mold arises).
[0029] Before carrying out the laminating of two or more metal plates, after establishing a surface defecation (cleaning) process and carrying out the laminating of further two or more metal plates, the reason for having established the process which joins the point is the same as the above-mentioned 1st operation gestalt.
[0030] That is, the manufacture approach concerning the 2nd operation gestalt of this invention is an approach (2) mean particle diameter manufactures the metal plate 1 micrometer or less which overly consists of a detailed grain using the rolling approach of giving the large strain of arbitration like the above-mentioned 1st operation gestalt, without changing (1) board thickness into the metal plate of a double width long picture.
[0031] (1) The rolling approach of giving the large strain of arbitration, without changing board thickness (approach A)
It is [ the above-mentioned 1st operation gestalt and ] the same (however, with this operation gestalt, in order to roll out at a room temperature, heating before rolling in a process (III) is not performed.).
[0032] (2) How (approach B) to manufacture the metal plate with a particle size of 1 micrometer or less which overly consists of a detailed grain
-izing of the diameter of average crystal grain can be carried out [ detailed ] to 1 micrometer or less by heating in the temperature region from which recovery arises under with the recrystallizing temperature (temperature of the minimum to which recrystallization of a nucleation and a growth mold takes place) after repeating rolling until it arrives at a ductile limitation by Approach A at a room temperature, without heating an ingredient with the ingredient which has ductility at the target room temperature in this operation gestalt, and annealing. The reason is as follows. In the metallic material which has ductility at a room temperature, if dislocation density will be in a work-hardening condition high enough by repeating rolling by Approach A in a room temperature, the rearrangement of the rearrangement by partial recovery will happen also in a room

temperature, and subgrain will be formed partially. However, most continues being the detailed cellular structure with which the rearrangement became entangled. Although a rearrangement accumulates this cell wall on high density extremely, the bearing difference of the cel of those both sides increases with the repeat of rolling by Approach A like the case of subgrain. If an ingredient with the detailed big cellular structure of such a partial bearing difference is heated in the temperature region where recovery takes place, the large cell wall of a partial bearing difference will change to a large inclination grain boundary, and a cel will become the super-fine crystal grain surrounded by the large inclination grain boundary.

[0033] In addition, although the ingredient which has ductility at a room temperature here means the ingredient which can be rolled out, without producing a crack to big rolling reduction at a room temperature, for example, fcc metals with the comparatively low melting point, such as aluminum and Cu, or those low alloys are main, ductile high bcc metals, such as pure iron, super-low carbon steel, or IF steel, are also contained. However, with a metal with the comparatively high melting point, since junction at a room temperature becomes difficult, three-sheet pack rolling (67% of rolling reduction) is needed. metal plates, such as a metallic thin plate of all the double width long pictures that can be manufactured with rolling in this invention as described above, -- receiving -- plate Koichi -- the large strain of arbitration is given by the law, and since it is possible to make the diameter of average crystal grain detailed to 1 micrometer or less, it becomes possible overly to mass-produce a detailed organization high intensity metal plate industrially, without receiving constraint of a material and product board thickness.

[0034] The example of this invention is given to below and the effectiveness of this invention is proved.

[0035]

[Example] Industrial-use pure aluminium (1100) and the application result to an aluminum-4.5%Mg-0.6%Mn alloy (5083): (Example 1) Rolling was repeated for 1mm in thickness, width of face of 20mm, the initial particle size of 37 micrometers (1100), and 18 micrometers (5083) O material by the two-sheet pile method at 200 degrees C (recovery temperature). The change to the count of repeat pack rolling of tensile strength and elongation (1 / piece of 5 trials of a JIS No. 5 test piece) in the room temperature of the plate obtained by drawing 2 is shown. With 1100 alloys, above six cycles, it reaches by 300MPa(s) and 3.6 times the start material (O material), no less than 5083 alloys reach by 550MPa(s) and 1.7 times the start material in 7 cycles, and tensile strength is rising further. Elongation does not fall any more, even if the number of cycles increases, although it falls to about 7%. The transmission electron microscope image of the aluminium alloy (1100 5083) by which repeat pile junction rolling was carried out [ above-mentioned ], and the photograph of the selected-area-micro-diffraction graphic form of the core (diameter of 1.6 micrometers) are shown in drawing 3 . The transmission electron microscope image and the photograph of a selected-area-micro-diffraction graphic form of 1100 alloys with which repeat pile junction rolling of drawing 3 (a) was carried out 8 times, and drawing 3 (b) are the transmission

electron microscope images and the photographs of a selected-area-micro-diffraction graphic form of 5083 alloys by which repeat pile junction rolling was carried out 7 times. As for the transparency microscope image and its selected-area-micro-diffraction graphic form of drawing 3 (a) and (b), any alloy shows the polycrystal-ized thing with a mean particle diameter of 1 micrometer or less for which the detailed grain organization is overly formed.

[0036] The application result to super-low carbon IF (Interstitial Free) steel: (Example 2) Two-sheet pack rolling was repeated for Ti addition IF steel (C:20 ppm, Mn:0.17%, Ti:0.07%) with the thickness of 1mm, a width of face [ of 20mm ], and an initial particle size of 27 micrometers at 500 degrees C (recovery temperature) whenever [ stoving temperature ]. The change to the count of repeat pack rolling of tensile strength and elongation in a room temperature is shown in drawing 4 . Tensile strength reaches by 760MPa(s) and 2.7 times the start material in 5 cycles, and elongation does not lose 6% and ductility. In 7 cycles, tensile strength reaches by 870MPa(s) and 3.1 times the start material.

[0037] The transmission electron microscope image of the Ti addition IF steel by which repeat pile junction rolling was carried out [ above-mentioned ] 7 times, and the photograph of the selected-area-micro-diffraction graphic form of the core (diameter of 1.6 micrometers) are shown in drawing 5 . As for the transmission electron microscope image and its selected-area-micro-diffraction graphic form of drawing 5 , mean particle diameter shows that he is [ 1 micrometer or less ] overly a detailed grain organization.

[0038]

[Effect of the Invention] As explained above, according to this invention, the new manufacture principle and the manufacture approach overly of mass-producing industrially metal plates, such as double width sheet metal of a detailed organization high intensity metallic material ******** super metal, that particle size consists of a fine crystal grain 1 micrometer or less can be offered by specifying rolling in the warm-rolling conditions of repeat pile junction rolling, or a room temperature, and annealing conditions.

[0039] The manufacture approach of this invention is applicable to metal plates, such as a metallic thin plate of steel, aluminum and an aluminium alloy, copper and a copper alloy, nickel and a nickel alloy, titanium and a titanium alloy, magnesium and a Magnesium alloy, and all the other double width long pictures that can be manufactured with rolling.

[0040] moreover, it is manufactured by this invention -- a detailed organization high intensity metallic material (the so-called super metal) is overly applicable to an automobile, the aircraft, a space plane, a rail car, etc. from a viewpoint of saving resources, energy saving, and an environmental adaptation ingredient -- etc. -- the utility value on industry is large.

---

[Translation done.]

## DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] Drawing showing the repeat pile junction rolling approach between ** concerning the gestalt of operation of this invention.
[Drawing 2] Drawing showing the tensile strength of an aluminium alloy and the change of an elongation percentage by the count of repeat pile junction rolling concerning the example 1 of this invention.
[Drawing 3] The transmission electron microscope image of the aluminium alloy by which heavy junction rolling was repeatedly carried out at 200 degrees C concerning the example 1 of this invention, and the photograph of the selected-area-micro-diffraction graphic form of the core (diameter of 1.6 micrometers). (a) is the transmission electron microscope image and the photograph of a selected-area-micro-diffraction graphic form of 1100 alloys by which repeat pile junction rolling was carried out 8 times. (b) is the transmission electron microscope image and the photograph of a selected-area-micro-diffraction graphic form of 5083 alloys by which repeat pile junction rolling was carried out 7 times.
[Drawing 4] Drawing showing the tensile strength of IF steel and the change of an elongation percentage by the count of repeat pile junction rolling concerning the example 2 of this invention.
[Drawing 5] The transmission electron microscope image of IF steel by which repeat pile junction rolling was carried out 7 times at 500 degrees C concerning the example 2 of this invention, and the photograph of the selected-area-micro-diffraction graphic form of the core (diameter of 1.6 micrometers).
[Drawing 6] Drawing showing the low-temperature large pressing-down rolling-out method.
[Drawing 7] Drawing showing a shear extrusion method (the ECAP method).
[Drawing 8] Drawing showing the mechanical milling method of fine particles.
[Description of Notations]
1, 1', and 1" -- metal plate and 2 -- -- reduction roll, and steel wire brush, 3 -- spot welder, 4 -- heating furnace, 5, and 5 '6, 6' -- a side-thrust-roller guide (or edging roll), 7 -- metal plate, and 8 -- cutter.

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

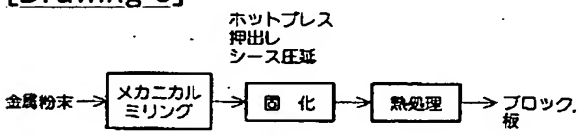
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

---

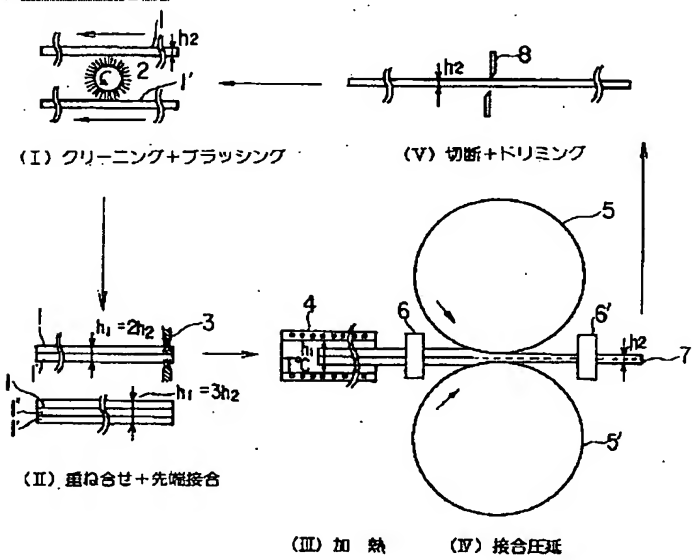
## DRAWINGS

---

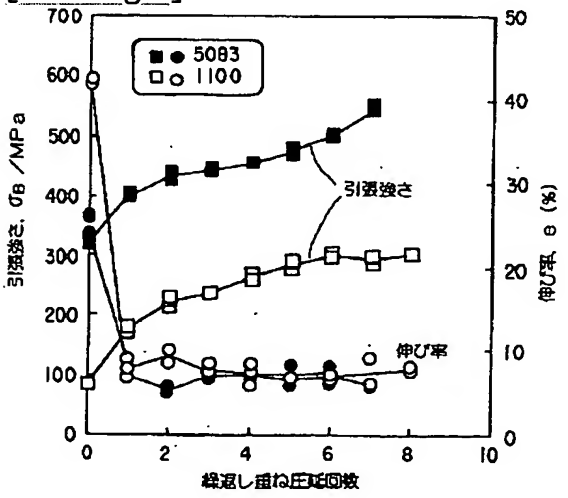
[Drawing 8]



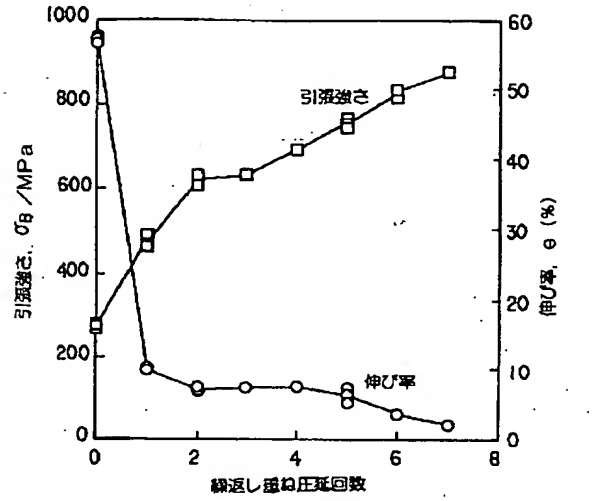

[Drawing 1]



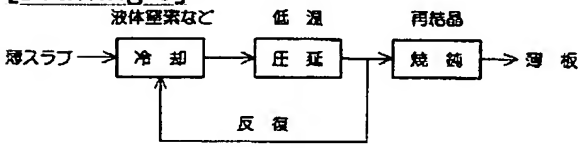

[Drawing 2]



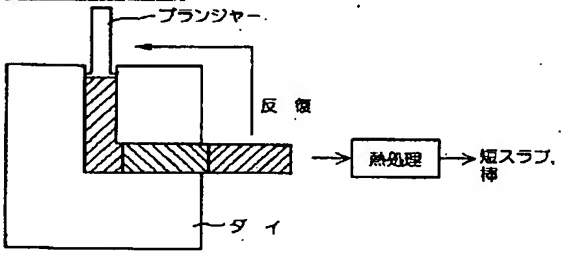
[Drawing 4]




[Drawing 6]

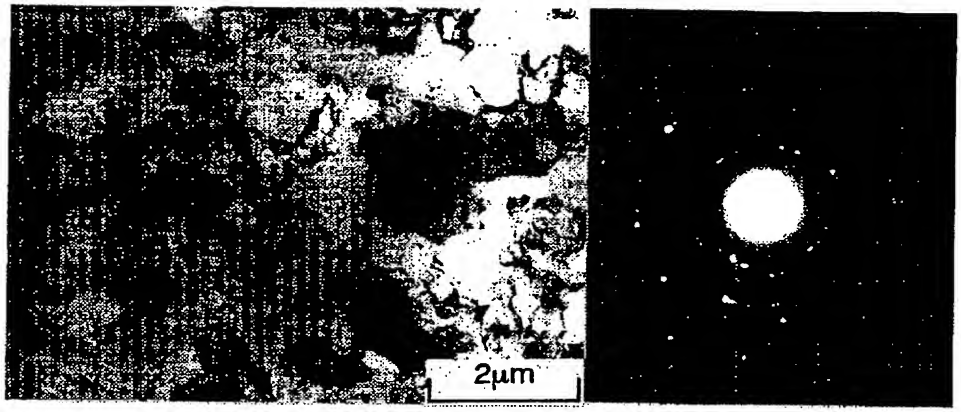



[Drawing 7]

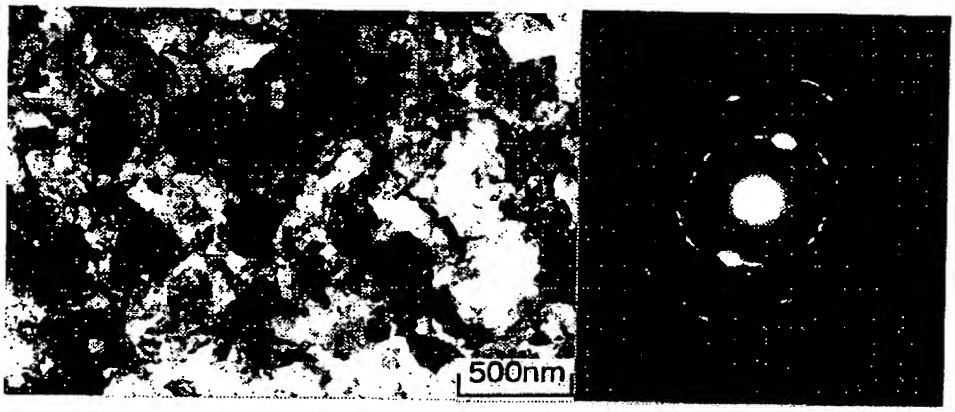



[Drawing 3]

図面代用写真



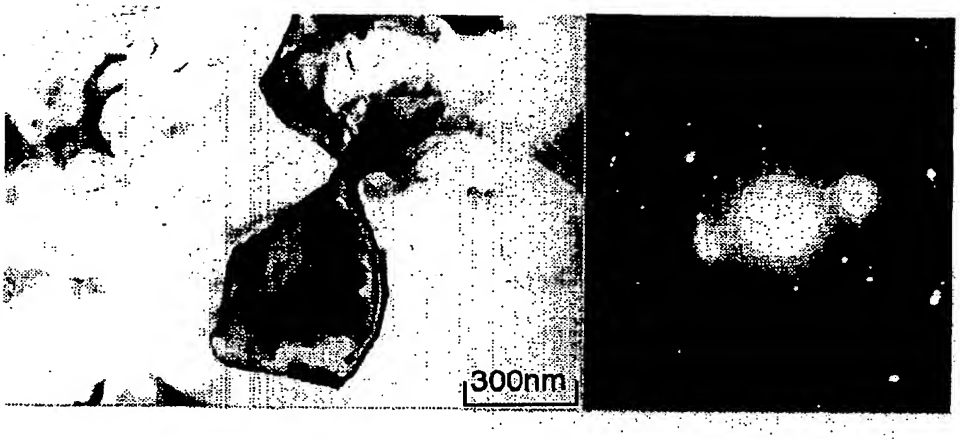

(a) 8回繰り返し重ね接合圧延された1100合金




(b) 7回繰り返し重ね接合圧延された5083合金

[Drawing 5]

図面代用写真




５００℃で７回繰り返し重ね接合圧延された
ＩＦ鋼の透過電子顕微鏡像とその制限視野回折図形

---

[Translation done.]

This Page is inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

# BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- [x] BLACK BORDERS
- [x] IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- [x] FADED TEXT OR DRAWING
- [ ] BLURED OR ILLEGIBLE TEXT OR DRAWING
- [ ] SKEWED/SLANTED IMAGES
- [x] COLORED OR BLACK AND WHITE PHOTOGRAPHS
- [ ] GRAY SCALE DOCUMENTS
- [ ] LINES OR MARKS ON ORIGINAL DOCUMENT
- [ ] REPERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- [ ] OTHER: _____

**IMAGES ARE BEST AVAILABLE COPY.**
**As rescanning documents *will not* correct images problems checked, please do not report the problems to the IFW Image Problem Mailbox**